the intestine is neural, and they take a very natural position among the neural mollusks between the Polyzoa on the one hand, and the Lamellibranchs and Pteropoda on the other.

The arms of the Brachiopoda may be compared with those of the Lophophore Polyzoa, and if it turns out that the so-called hearts are not such organs, one difference will be removed.

In conclusion, I may repeat what I have elsewhere adverted to, that though the difference between the cell of a Polyzoon and the shell of a Terebratula appears wide enough, yet the resemblance between the latter with its muscles and the Avicularium of a Polyzoon, is exceedingly close and striking.

VIII. "An Inquiry into some of the circumstances and principles which regulate the production of Pictures on the Retina of the Human Eye, with their measure of endurance, their Colours and Changes."—Part II. By the Rev. WILLIAM SCORESBY, D.D., F.R.S., Corresp. Inst. of France, &c. Received May 31, 1854.

This second part of the author's inquiries concerning phenomena in optical spectra, embraced the results in respect of *colour* in the images impressed on the retina, as derived simply from the influence of *light*.

The optical spectra from white, grey, or black opake objects under faint illumination, or of ordinary windows or apertures transmitting low degrees of light, were usually found to be without colour. But ordinary daylight, and, much more, the light from bright sunshine (as is well known), yield *chromatic spectra* of vivid or brilliant hues. By viewing with slightly closed eyes, the pictures impressed on the retina by a few seconds' steady gazing at some fixed point of an illuminated object, and noting the various effects, disappearances and changes, a considerable number of characteristic phenomena were elicited, and the effects of a variety of modifying circumstances satisfactorily determined. The most prevailing influences in modifying the phenomena—whatever other causes might tend to the production of variation in the colours—were found to be referable to differ-

ences in the degree of intensity of the external light, in the extent of time occupied in gazing at the illuminated object, in the quantity of light penetrating the chamber of the eye whilst examining the spectra, and in the normal condition of the eye itself. These, with other modifying circumstances, had been somewhat elaborately investigated.

Different degrees of light, whether reflected from white objects, or transmitted by colourless glass, had obviously the tendency to yield differences in the colours of the primarily developed pictures on the retina, with corresponding varieties in the nature and number of the subsequent changes. Thus the viewing for a few seconds of an aperture in a window the size of a pane of glass, whilst all the rest was covered with a thick brown-paper screen, gave, *with a low degree of daylight,* transparent pictures of a *dingy* orange, olive, yellow-grey or bluish black tint, changing, most usually, into a rusty-tinted blackish spectrum, and disappearing, for the most part, in a minute of time or less. From *medium degrees of daylight,* the primary pictures embraced a considerable variety of colours, such as crimson-pink, purple-pink, violet, purple, indigo, blue,—the blue being the highest in the scale of intensity. The most marked changes, commencing with *blue,* were usually from blue to red, or to crimson, olive, black fading into blackish grey. In certain cases rapid and evanescent glances were had of several intermediate colours. The general photochromatic effects of the *higher degrees of light,* such as from a clear sky in full sunshine, were far more uniform than those from inferior light. The spectrum first elicited, even after viewing a window or window-aperture for three or four seconds only, was almost always *green,* with the character of illuminated transparency; the shades of colour however varied with the intensity of the impression. The picture always appeared within four or five seconds after closing the eyes, and when the light had been strong and the gazing continued for a quarter of a minute or more, the picture would burst out almost instantly. The restoration of the picture in new colours, after the vanishing, had very much the character and appearance of the dissolving views effected by the magic lanthorn. *The frame* of the window or aperture, and the cross-bars, were always pictured in colours different from those of the panes, besides a fine marginal line of another colour dividing the

glass and the frames. These *consequential colours*, constitute, as is well known, a remarkable feature in the phenomena. They have generally a certain complementary relation, or tendency to such, to the colours of the primary picture. Thus in the clear green or blue spectrum of a window, derived from strong illumination, the remainder of the field of the eye will generally, in *the first* instance, be covered with a ground of glowing crimson, with cross-bars similar, and purple edgings; and when the picture changes to crimson or red, the antagonistic tint will also change, perhaps to purple, or orange or brown. The original spectra were found to fade away at intervals, often of tolerable equality, such as of eight or nine seconds, disappearing perhaps for two or three seconds, and then reappearing under, generally, some change of shade or tint, through an extent of very numerous repetitions. The changes of colour from the bright or emerald green, as very frequently traced, went rapidly through yellow-green, yellow, orange, red, scarlet, crimson and brown, or olive. And this series, it is observable, is particularly accordant, in respect to the principal or fundamental colours, with that of the prismatic spectrum from green to yellow, orange and red. These visual photographs, besides having the sharpest definition, and often the most brilliant illuminated colours, were found to possess, under strong intensities of impression, a remarkable degree of permanency—extending sometimes to endurance for an hour or longer after the act of gazing.

Investigations on the relation of the photochromatic developments to the time of gazing, gave results in many respects corresponding with those derived from differences in the degree of external light. Thus the higher colours of the spectral series elicited by strong light, could, within certain limits, be also developed by more continuous gazing with inferior light: so that the pink-coloured spectrum derived from ten to twenty seconds' gazing in low degrees of light, could be elicited by a single glance under bright sunshine. The results, therefore, were clearly in relation to the intensity of the impression; and, taken in the form of a general proposition, we shall not be far wrong, perhaps, in considering the intensity of impression as the product of the time of gazing into the relative quantity of light admitted by the aperture.

The relation of the colours primarily elicited to the intensity of

the impression, yielded (comparatively and roughly taken) the following series,—crimson-pink, purple-pink, purple, blue, green, the latter being the produce of the highest intensity tried.

As in the foregoing researches, the relative degrees of light were but broadly assumed, whilst the comparative experiments comprised a variety of differences affecting the photochromatic results, another series of experiments on the simple effects of degrees of light was instituted, in which all these other differences were eliminated. In this series the quantity of light was varied by partial or sectional screens of glass, or other transparent or semitransparent substances. The results were particularly satisfactory,—different tints or shades of colour being obtained by the same view and in the same spectrum of a window-aperture, when different thicknesses of window glass were placed in the several sections (six in number) into which the aperture was divided.

A beautiful example of the chromatic effects of partial and varied screening of light on the optical spectrum elicited, was incidentally obtained by viewing an aperture in the clouds, when the sky was otherwise densely covered. After gazing for a few seconds on the middle of this aperture, the spectrum, as viewed with gently closed eyes, exhibited a singular variety of the richest tints according to the differences in the light screened off by the edges of the cloud and by certain little patches within the aperture. The spectrum resembled the variegation and richness of colouring as elicited in certain transparent or semitransparent substances when examined by polarized light.

The experiments on binocular and multiple spectra, as described in Part I. of the author's paper, being repeated under degrees of light adequate for yielding *colour*, gave pictures, in many cases, of much interest and beauty. The multiple spectra, however, which proved the most strikingly beautiful, were derived from the sun, which was viewed *indirectly*, and on occasions, near setting, in winter, when the intensity of its light was duly subdued by passing through a dense condition of atmosphere. Under such circumstances, images, sometimes in 100 to 150 repetitions, were impressed on the retina by rapid glances at the sky immediately around the sun. These were taken by quick movements of the head, winking intermediately, at the rate of 60 to 120 impressions in the minute; and the result,

when viewed with closed eyes, presented a splendid spectacle like a cluster of coloured stars, or rather of round planetary discs, brilliant in green, yellow, orange, red, crimson and purple!

Besides the experiments thus far described, in which the spectral images were viewed, for the most part, with gently closed eyes kept steadily in the direction in which the objects were gazed on,—the differences, which were often very remarkable, produced by alterations in the quantity of light admitted into the chamber of the eye whilst the image was viewed, were also investigated. Sometimes the smallest change in the light thus transmitted was found to alter greatly the character of the spectrum. In certain cases, the compressing of the eyelids, or the mere passing of the hands betwixt the eyes and the light, would serve to change a negative picture into a positive, or the colours, as viewed in the usual way, into their complementary tints.

The paper concludes with a considerable series of deductions, applications and general results.—1. As to the *elucidation* yielded by these ocular spectra, of the theory of vision.—2. Of the principles of binocular and simple vision.—3. Of the action of the retina for the obliterating of impressed images, and the recovery of a normal condition.—4. Of the nature of certain disturbing and dazzling effects of vision by strong light.—5. Of the phenomena of certain spectral illusions.—6. As to the *practical use* of the process of examining the ocular spectra, for the determination of quantities of light relatively intercepted by different portions or thicknesses of glass or other transparent media.—7. For assisting in the determination of the relative degrees of illumination of lamps, candles, &c., and of quantities of light reflected from opake objects.—8. For aiding in the selection and harmonizing of colours in ornamental and decorative departments of art.—9. For the examination of the condition of the interior of the eyes in certain states of disease. The author having had the opportunity of trying this process in case of amaurosis, found that it afforded a perfect picture of defects in the surface of the retina of the eyes separately, when there was no visible defect, and when the patient had no other perception of a diseased eye, or patch on the retinal surface, except the partial distortion or interruption of vision. Founded on this, the author suggests a plan of *scotometrical* examination of retinal defects, by which not only the accurate

form and relative proportions of diseased patches on the retina may be determined, but their actual dimensions may probably be deduced.

IX. "On the frequent occurrence of Indigo in Human Urine, and on its Chemical, Physiological and Pathological Relations." By ARTHUR HILL HASSALL, M.D., Member of the Royal College of Physicians, Physician to the Royal Free Hospital, &c. Communicated by Professor SHARPEY, Sec. R.S. Received June 10, 1854.

The present communication embraces some further observations and experiments on the occurrence of indigo in human urine. From these it appears that the presence of that substance is even more common than the author was led to anticipate from his first inquiries, the results of which were communicated to the Society in June last.

The author furnishes additional proofs of the blue colouring matter in question being really indigo, by converting it into isatine and aniline; for this purpose it was necessary to obtain the pigment in considerable quantity.

Contrasting its chemical and physiological relations with hæmatine and urine pigment, he shows that indigo is closely allied in its nature and origin to those substances, and he considers that when indigo is met with in urine in considerable amount, it forms a vehicle for the elimination of any excess of carbon contained in the system. This view is borne out by the important fact, that the greater number of cases in which indigo has been observed to be developed in the urine in large amount have been cases of extensive tubercular disease of the lungs, and in which the decarbonizing functions of those organs are greatly impaired.